InkBiology

ANSWER BOOK

Spending ATP to make ATP: glycolysis and the link reaction

Respiration and cellular energy · Unit B12

AQA 3.5.2 · OCR A 5.2.2 · Edexcel A Topic 7.3–7.4 · CAIE 12.1, 12.2

6 questions · 20 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 **B1** glycolysis takes place in the cytoplasm of the cell. **B1** the link reaction takes place in the matrix of the mitochondrion. [2]

SECTION B · Standard, 3 to 5 marks

B1 **B1** phosphorylation: two molecules of ATP are hydrolysed and their phosphate groups added to glucose, giving hexose bisphosphate, which is less stable and more reactive. **B1** lysis: the six-carbon hexose bisphosphate splits into two three-carbon molecules of triose phosphate, so everything after this point happens twice per glucose. **B1** oxidation: hydrogen is removed from each triose phosphate and taken up by NAD, giving two reduced NAD per glucose, and pyruvate is what remains. **B1** phosphate groups are transferred directly from the intermediates onto ADP by substrate-level phosphorylation, making four ATP per glucose, so the net yield is 2 ATP, 2 reduced NAD and 2 pyruvate. [4]

B2 **M1** per molecule of glucose, glycolysis produces 4 ATP, uses 2 ATP and forms 2 reduced NAD. **A1** 4 × 8 = 32 molecules of ATP produced. **A1** 2 × 8 = 16 molecules of ATP used, so the net gain is 32 - 16 = 16 ATP. **A1** 2 × 8 = 16 molecules of reduced NAD. [4]

B3 **B1** pyruvate is carried from the cytoplasm across both mitochondrial membranes into the matrix by a transport protein. **B1** it is decarboxylated: one carbon is removed and released as carbon dioxide, which is the first carbon dioxide respiration produces. **B1** it is dehydrogenated: hydrogen is removed and taken up by NAD, giving one reduced NAD. **B1** the two-carbon acetyl group left behind joins coenzyme A to form acetyl coenzyme A, and because the reaction runs twice per glucose the products are 2 CO_2, 2 reduced NAD and 2 acetyl CoA, with no ATP made. [4]

B4 **B1** hydrolysis of the terminal phosphate of ATP, catalysed by ATP hydrolase, releases about 30.5 kJ per mole in a single step, so the energy is available at once with no chain of intermediates to wait for. **B1** that quantity is small enough to be useful for a single reaction, so little is wasted as heat, whereas releasing the 2880 kJ per mole held in glucose in one go would damage the cell. **B1** the reaction is easily reversed, because ATP synthase joins ADP and inorganic phosphate back together, so the same molecules are recycled thousands of times a day rather than being stockpiled. [3]

B5 **B1** glycolysis takes place in the cytoplasm and needs neither oxygen nor a mitochondrion, so the cell can still carry it out and make ATP by substrate-level phosphorylation. **B1** the cell cannot carry out the link reaction, the Krebs cycle or oxidative phosphorylation, because those need the matrix and the inner membrane. **B1** so it gains only the net 2 ATP from glycolysis, under three per cent of the energy held in a molecule of glucose, and it must respire a great deal of glucose to meet its demand. [3]